Q.2. Write short note on properties of X-ray.

(Oct 2017, 5 Marks)

Ans. Properties of X-ray are of following, types i.e.

- Physical properties
- Chemical properties
- Biological properties
- Physiochemical properties

Physical Properties

- X-rays are electromagnetic radiation having a wavelength between 10 Å to 0.01Å.
- In free space, they travel in straight line.
- They travel with the same speed as that of visible light, i.e. 1,86,000 miles/sec.
- They are invisible to eye and cannot be seen, heard or smelt.
- They cannot be reflected, refracted or deflected by magnet or electric field.
- They show the properties of interference, diffraction and polarization similar to visible tight.
- They can produce an electrical field at right angles to their path of propagation and a magnetic field at right angles to the electric field and propagation.
- They do not require a medium for propagation.
- Penetration of X-rays can penetrate liquids, solids and gases. The degree of penetration depends upon the quality of the X-ray beam and also on intensity and wavelength of X-ray beam.
- Absorption X-ray are absorbed by matter, the absorption depends on the atomic structures of the matter and the wavelength of X-ray.
- Ionizing capability: X-rays interact with materials they penetrate and causes ionization.
- Fluorescence: When X-rays fall upon certain materials, visible light is emitted called fluorescence.
- X-rays has the property of attenuation, absorption and scattering.
- Heating effect.

Chemical Properties

- X-ray induces color changes of several substances or their solution, e.g. methylene blue gets bleached.
- X-ray bring about chemical changes in solution because X-rays produce highly active radical "OH" in water, which reacts with the solutes.
- X-ray can cause destruction of the fermenting power of enzymes.

Biological Properties

- The "excitation" property of X-rays are used in treatment of malignant lesions.
- X-rays also have a germicidal or bactericidal effect (sterilization and preservation of food).
- *Somatic effect:* This ranges from simple sun burn to severe dermatitis or to change in blood supply to malignancy.
- *Genetic effect:* Effect due to radiation induced mutation of genes and chromosomes.

Physiochemical Properties

- X-ray can produce an image on a photographic film.
- Photographic film when exposed to X-ray radiation and then developed will be found blackened. Irradiation affects the silver salt in emulsion, so after developing the, radiograph metallic silver releases and films appear black.

Q.3. Write in detail about interaction of X-rays with matter.

(Oct 2017, 10 Marks)

Ans. As X-rays strike the matter such as tissue of the patient, photons interact with atoms in the absorber and have three possible fates, i.e.

1. Coherent scattering (8%)
2. Photoelectric effect (30%)
3. Compton scattering (62%)

Coherent Scattering

- It is also known as classical or elastic or Thompson scattering.
- Coherent scattering is the process by which radiation is deflected without losing energy.
- X-rays when pass close to an atom causes bound electrons to vibrate momentarily at a frequency which is equal to that of incident photon and the incident photon ceases to exist.
- The vibration causes electron to radiate energy in form of another X-ray photon of same frequency and energy as that in the incident beam. Usually, the second photon emitted is at an angle to the path of incidental X-ray.
- This interaction accounts for only 8% of total number of interactions in the dental examination.
- Coherent scattering is negligible in production of fog. This property is used to investigate internal molecular structure of materials by method of X-ray diffraction known as X-ray crystallography.

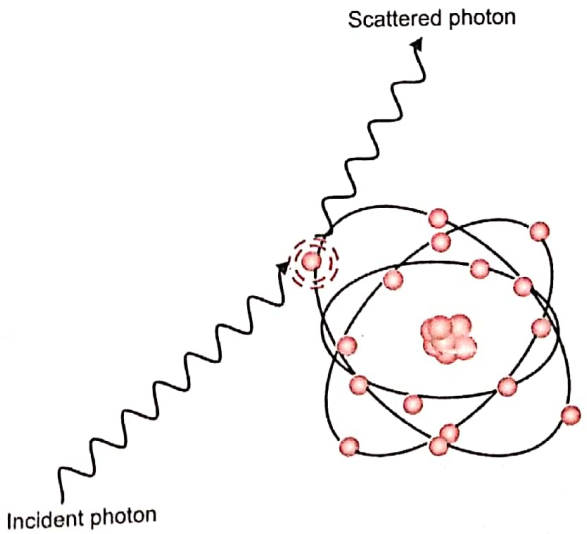

Fig. 1: Coherent scattering

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- *Once calcification starts:* Hypoplastic changes seen.
- *During root development:* Retardation or loss of root development.

After Eruption

Radiation caries: It is a form of rampant caries; it is secondary to the change in saliva.

Effects on Bone

- Marrow is replaced by bone marrow and fibrous connective tissue.
- Endosteum becomes atrophic.
- Bone becomes hypovasular hypocellular and hypomineralized.
- The complication following irradiation, i.e. "osteoradionecrosis".
- Necrosis of bone may result in nonhealing ulcer which may occur after tooth extraction.
- Lack of osteoblastic and osteoclastic activity in endosteum.
- Mandible affects more than maxilla.

Acute Radiation Syndrome

When the whole body is exposed to low or moderate doses of radiation, a very characteristic change are seen known as acute radiation syndrome. This can be followed by death within a month. If an individual survive, it can show late somatic changes which are:

- *Prodromal syndrome (1 to 2 Gy):* Shortly after exposure patient may develop nausea, vomiting, diarrhea and anorexia.
- *Latent period:* It is a period of apparent well being, the extent of which is dose related. Symptoms follow the latent period when the individuals are exposed in the lethal range (approximately 2–5 Gy) or the supralethal range (more than 5 Gy).
- *Bone marrow (hemopoietic) syndrome {2 to 7 Gy):* Here severe damage may be caused to the circulatory system. The bone marrow being radiosensitive, results in fall in the number of granulocytes, platelets and erythrocytes. Clinically, this is manifested as lymphopenia, granulocytopenia and or hemorrhage due to thrombocytopenia and anemia due to depletion of the erythrocytes.
- *Gastrointestinal syndrome (7 to 15 Gy):* This causes extensive damage to the gastrointestinal tract, leading to anorexia, nausea, vomiting, severe diarrhea and malaise. Injury to the basal cell epithelial cells of the intestines causes denuded mucosal surfaces, leading to loss of plasma and electrolytes, hemorrhage and ulcerations leading to diarrhea, dehydration and loss of weight. Finally, leading to septicaemia unusually leading to death.
- *Cardiovascular and central nervous system syndrome (more than 50 Gy):* This produces death within one or two days. Individuals show intermittent stupor, incoordination, disorientation and convulsions suggestive of extensive damage to the nervous system.

Protection from Hazards of Radiation

Protection of Patient

- *X-ray machine:* Good machines of reputed companies should be used.
- *Selection of film:* F- and E-speed films are used as they are of good quality and are highly sensitive. E speed films or Ekta speed films reduce exposure to 40%.
- *Focal spot film distance:* Longer is the focal spot film distance decrease is in the exposed tissue volume.
- *Source skin distance:* Increase in the source skin distance reduces the size of beam and reduces the volume of tissue irradiation which decreases the patient dose.
- Filtration: Low energy X-ray beam is removed by the filtration. As these X-rays do not contribute to the image formation they should be removed before they reach to the patient as they lead to the radiation exposure.
- *X-ray collimation:* It prevent the scattering. Beam should be collimated so that it is not more than 7 cm in diameter at the face of patient. Rectangular collimators should be preferred as they reduce the amount of tissue radiation.
- *Intensifying screen:* Use of rare earth screen decreases dosage for extraoral films.
- *Grid:* Grid decreases the fogginess of film due to the secondary radiation, this reduces the need for repeating the film.
- *Kilovoltage:* Operation of X-ray unit should be done at 60 to 90 kVp. X-ray beam of low kilovoltage leads to the higher patient doses, mainly to skin.
- *Position-indicating devices:* A 12 to 16 inches long position indicating device reduces exposure to patient as compared to short position indicating device. Open ended, circular or rectangular lead-lined cylinders are preferred to direct the X-ray beam.
- Lead aprons should be used who have lead content equivalent to 0.25 mm aluminum which is to be worn by patient during taking the radiograph.
- Thyroid collars should be weared to protect thyroid gland from radiation.
- *Film-holding devices:* They stabilize the X-ray film in mouth and so the hands of patient are not exposed to radiation.
- *RVG:* It decreases the dose of radiation required in IOPA.

Protection of the Operator

- Operator should not hold X-ray film in mouth of patient at the time of exposure.
- Operator should not stabilize the X-ray machine at the time of exposure.
- Operator should not stand in the path of primary radiation.
- Operator should have to stand behind a lead barrier which consists of 0.5 mm lead equivalent during the exposure.
- Operator should stand 6 feet away from primary X-ray beam.
- Operator should have radiation exposure monitored by personal monitoring devices or film badges.

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an angle of 90 to 135° with respect to direction of central rays.

- This rule takes advantage of inverse square law to reduce the intensity and also considers that in this position patient's head will absorb most scattered radiation.

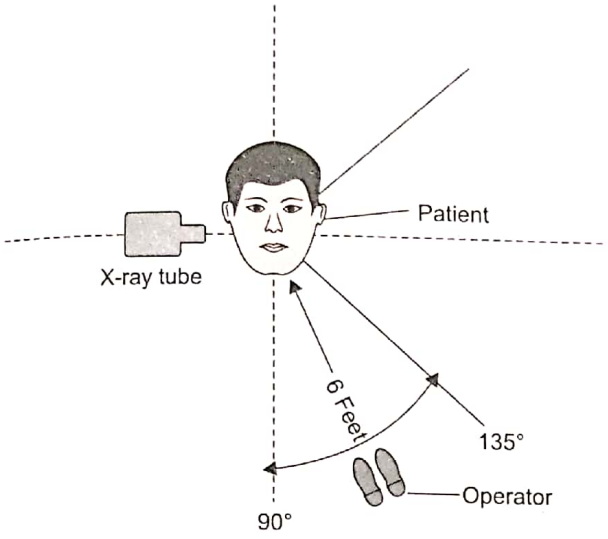

Fig. 12: Position for operator

Q.7. Write short note on TLD badges.
(Oct/Nov 2014, 3 Marks) (Oct 2016, 5 Marks) (Oct 2017, 5 Marks)

Or

Write short note on TLD *(Mar 2015, 5 Marks)*

Ans. The full form of TLD badge is Thermoluminescence Dosimeter badge.

- TLD badge is used for measurement of actual dose received by operator or patient due to radiography or radiotherapy exposure and are personal monitoring devices.
- It is easily placed over the body since its size is very small.

Structure of TLD Badge

- TLD badge in India consists of TLD card holder cassette which is made up of high impact plastic, TLD card has nickel plated aluminum plate consisting of three symmetrical holes in which calcium sulphate embedded Teflon disks are inserted.
- These teflon disks are clipped on aluminum card which is loaded in cassette and consists of three filters, i.e. open region, copper and aluminum.

Principle of TLD Badge

- When phosphorous is irradiated the X-ray energy is absorbed and secondary electrons are emitted.
- Secondary electrons create holes in filled zone by lifting electrons to conduction band.
- Here the electrons fall back in traps in metastable state where they held up.
- When phosphorus is heated at 2000 to 3000°C the trapped electrons acquire energy to escape back to conduction band.
- From conduction band, the electrons fall back to fill holes in filled zone when they recombine visible light is produced known as thermoluminescence.

TLD Reader

- Equipment which heat the exposed material and measure emitted light is known as TLD reader.
- Reading produced by TLD reader is used as a measure of absorbed dose to which material is subjected.
- It consists of three parts, i.e. heater, photomultiplier tube and electronic system.

Wearing of TLD Badge

- Chest badge consists of metallic clip which is to be worn outside the clothes. It should be kept below lead apron.
- Wrist badges consist of snap for attachment.

Indications

- In radiotherapy
- In radiodiagnosis
- For personal monitoring

Advantages

- It is chemically inert.
- Size is small and light in weight.
- Reusable
- Provide accurate readings
- It is economical
- Can be used for various range of radiation qualities.

Disadvantages

- Provide limited information.
- Dose gradients are not detected.
- Records are not permanent.

Q.8. What is ALARA principle. Discuss the radiation protection for dental patient.
(Oct 2015, 16 Marks)

Ans. ALARA means "as low as reasonably achievable" ALARA principle recognizes the possibility that no matter how small the dosage is some stochastic effect may occur.

ALARA principle is as follows:

- *In radiation workers:*
  - Occupationally exposed person—50 mSv or 5 rem in any one year.
  - Women of reproductive age and pregnancy should not exceed 10 mSv or 1 rem.
- *Members of the public:*
  - Annual effective dose for public should not exceed 1mSv or 0.1rem.

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- The image is read by transferring each row of pixel charges from one pixel to the next in a "bucket brigade" fashion. As a charge reaches the end of its row, it is transferred to a read out amplifier and transmitted as a voltage to analog-to-digital convertor located within or connected to the computer.
- Voltages from each pixel are sampled and assigned a numeric value representing a gray level.

Clinical Applications

- Dental caries detection
- Intrabony defects
- Periapical pathologies detection
- Detection of root fractures
- Detection of root canal length
- Application in mentally retarded/developmentally disabled individuals
- In Telemedicine

15. RADIOGRAPHIC PRESCRIPTION, QUALITY CONTROL AND INFECTION CONTROL

Q.1. Describe in brief the steps in radiographic infection control. *(Mar 2011, 6 Marks)*

Ans. Following are the steps in radiographic infection control:

- Whole surface of X-ray machine should be covered with plastic.
- Ask the patient to wear lead apron and seat him/her in proper position.
- Dental healthcare worker should wash his/her hand with antiseptic and wear gloves.
- While exposing the film care is taken to touch only covered surface.
- From exposed film saliva is washed out and film is kept in disposable container outside the room.
- After discharging the patient discard contaminated barriers and disinfect or sterilize lead apron.
- Contaminated gloves are removed and film is carried to darkroom. Wear new gloves in darkroom.
- Remove film from barrier pouch and keep it on clean surface. Take care not to touch the film with gloved hand.
- Dispose wrapper and gloves.
- Processing of the uncontaminated film on clean surface is done.

16. NORMAL ANATOMY OF INTRAORAL AND EXTRAORAL RADIOGRAPHS

Q.1. Describe various anatomic landmarks seen on periapical radiographs. *(Mar 2000, 16 Marks)*

Or

Describe normal radiographic anatomical landmark of maxilla and mandible *(Mar 2017, 10 Marks)*

Ans. Radiographic appearance of various structures which are visualized on the intraoral periapical radiograph are classified as:

1. **Normal teeth anatomy in maxilla and mandible**
   a. Enamel
   b. Dentin
   c. Cementum
   d. Pulp cavity
2. **Supporting structures**
   a. Lamina dura
   b. Alveolar crest
   c. Periodontal ligament space
   d. Cancellous bone
3. **Maxilla**
   a. **Radiopaque bony landmarks of maxilla**
      - Nasal septum
      - Anterior nasal spine
      - Floor of nasal cavity
      - Inferior nasal conchae
      - Nasolabial fold
      - Floor of maxillary sinus
      - Septae in maxillary sinus
      - Inverted Y in maxillary sinus
      - Zygomatic process of the maxilla
      - Zygoma
      - Pterygoid plates
      - Hamular process
      - Maxillary tuberosity

   b. **Radiolucent bony landmarks of maxilla**
      - Nutrient canals
      - Inter – maxillary suture
      - Nasal fossa
      - Incisive foramen
      - Superior foramina of nasopalatine canal
      - Incisive fossa
      - Nasolacrimal canal
      - Maxillary sinus
      - Nose
4. **Mandible**
   a. **Radiopaque bony landmarks of mandible**
      - Genial tubercle
      - Mental ridge
      - Mylohyoid ridge
      - External oblique ridge
      - Inferior border of mandible
      - Coronoid process
      - Internal oblique ridge

   b. **Radiolucent bony landmarks of mandible**
      - Lingual foramen
      - Symphysis
      - Mental fossa
      - Mental foramen
      - Mandibular canal
      - Submandibular fossa

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Normal Teeth Anatomy in Maxilla and Mandible

- **Enamel:** This is the densest structure. It is seen as the outer most radiopaque layer of the crown of a tooth on the radiograph.
- **Dentin:** It is found beneath the enamel layer and surrounds the pulp. It is less radiopaque than enamel.
- **Cementum:** It is not usually apparent on the radiograph because the cementum layer is very thin.
- **Pulp cavity:** This consists of the pulp chamber and the root canals. It contains blood vessels and nerves and appears relatively radiolucent in the radiograph.

Supporting Structures

- **Lamina dura:** This is the wall of tooth socket that surrounds the teeth, it is made up of dense cortical bone. It appears as a thin dense radiopaque line that surrounds the root of the tooth.
- **Alveolar crest:** This is the most coronal portion of the alveolar bone found between the teeth. It appears as a radioopaque area located 1.5 to 2 cm below the junction of the crown and the root surfaces.
- **Cancellous bone:** This is soft spongy bone located between two layers of dense cortical bone. It is composed of numerous bony trabeculae. On radiograph, the cancellous bone appears as predominantly radiolucent with the trabeculae appearing radiopaque in a cris cross pattern.
- **Periodontal ligament space:** It is a space between the root of the tooth and the lamina dura. The PDL space contains connective tissue fibres, blood vessels and lymphatic. On radiograph, it appears as a thin radiolucent line of uniform thickness around the root of the teeth.

Radiopaque Bony Landmarks of Maxilla

1. **Nasal septum:** It is a vertical bony wall or partition that divides the nasal cavity into the right and left nasal fossa. It appears as a vertical radiopaque partition that divides the nasal cavity.
2. **Anterior nasal spine:** V-shaped radiopaque area located at the intersection of the floor of the nasal cavity and nasal septum.
3. **Floor of the nasal cavity:** Appear as dense radiopaque band above the maxillary incisors.
4. **Inferior nasal conchae:** A diffuse radiopaque mass or projection within the nasal cavity.
5. **Nasolabial fold:** It is an oblique line demarcating a region that appears to be covered by a veil of slight radiopacity which is seen in premolar region. Line of contrast is sharp and area of increased radiopacity is posterior to the line. Line is the nasolabial fold and veil is thick cheek tissue superimposed on teeth and alveolar process.
6. **Floor of maxillary sinus:** A radiopaque line appears at above the apices of maxillary molars is indicative of floor of maxillary sinus.
7. **Septa in maxillary sinus:** Boney projection or partition which appear to divide the sinus in compartments.
8. **Inverted-Y in maxillary sinus:** It is the intersection of maxillary sinus and nasal cavity. It appears as radiopaque upside down Y formed due to intersection of floor of nasal fossa and anterior border of maxillary sinus.
9. **Zygomatic process of maxilla:** "J" or "U" shaped radiopacity located superior to the maxillary first molar region.
10. **Zygoma:** A diffuse radiopaque band extending posteriorly form the zygomatic process of the maxilla.
11. **Pterygoid plates:** A single radiopaque homogeneous shadow immediately posterior to the tuberosity of the maxilla.
12. **Hamular plates:** It is a small hook like projection of bone extending from the medial pterygoid plate of the sphenoid bone.
13. **Maxillary tuberosity:** This is a rounded prominence of bone which extends posterior to the third molar region. On radiograph, it appear as a radiopaque bulge posterior to the third molar region.

Radiolucent Bony Landmarks of Maxilla

1. **Intermaxillary suture:** It is the immovable joint between the two palatine processes of maxilla. It extends from the alveolar bone between the maxillary incisor to the posterior hard palate. It appears as a thin radiolucent line between the maxillary central incisors.
2. **Nasal fossa:** It is a pear-shaped, air-filled compartment of bone located superior to maxilla. On radiograph, it appears as large radiolucent area above the maxillary incisors.
3. **Incisive foramen:** It is an opening located in the midline of the anterior portion of the hard palate posterior to central incisors. On radiograph it appears as a small radiolucent round area between the roots of maxillary central incisors.
4. **Superior foramina of nasopalatine canal:** It appears as two small radiolucent areas located superior to the apices of the maxillary central incisors, in the floor of the nasal cavity.
5. **Incisive fossa:** It is a smooth depressed area of maxilla located just inferior and medial to infraorbital foramen between lateral incisors and canine. On radiograph, it appears as a radiolucent area between canine and lateral incisor.
6. **Nasolacrimal canal:** It is formed by the nasal and maxillary bone, running from the medial aspect of the anteroinferior border of the orbit. On radiograph, it appears as a well-defined slightly ovoid radiolucency, just above the apex of the maxillary canine.
7. **Maxillary sinus:** These are paired three-sided pyramidal cavities of bone within the maxilla.
8. On the radiograph it appear as radiolucent area located above the apices of the maxillary molars.
9. **Nose:** Image of nose has uniform slight opaque appearance with sharp border and sometimes radiolucent nares can be identified.

Radiopaque Bony Landmarks of Mandible

1. **Genial tubercles:** These are tiny bumps of bone on the lingual side of the mandible in midline and serve as attachment for the genioglossus and the geniohyoid muscle. Radiographically appear as ring-shaped radiopacities below the apices of the mandibular incisors.

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2. **Mental ridge:** This is a linear prominence of cortical bony plate, located on external surface of the anterior portion of the mandible. It appear as a thick radiopaque band that extends from premolar to incisor region.
3. **Mylohyoid ridge:** This is a linear prominence of the bone located on the internal surface of the mandible, extending from molar region downwards and forwards towards the lower border of the mandibular symphysis.
4. **External oblique ridge:** It appears as a radiopaque band extending downwards and forwards from the anterior border of the ramus of the mandible.
5. **Inferior border of the mandible:** It appears as a dense radiopaque band of bone in the lower border of the mandible.
6. **Coronoid process:** It is a marked prominence of bone on the anterior ramus of the mandible. On radiograph, it appears as triangular radiopacity superimposed over or inferior to the maxillary tuberosity region.
7. **Internal oblique ridge:** On radiograph, it appear as a radiopaque band which extend downward and forward from the ramus.

Radiolucent Bony Landmarks of Mandible

1. **Nutrient canals:** They are tube like passages through the bone which consists of nerves and blood vessels which supply the teeth. On radiograph they appear as vertical radiolucent lines. They are prominent in anterior region and in edentulous mandible.
2. **Lingual foramen:** It is a tiny opening in the bone located on the internal surface of the mandible near the midline. It appears as a small radiolucent dot inferior to the apices of the mandibular incisors.
3. **Symphysis:** On radiograph, it appears as a radiolucent line through the midline of the jaw. After one year of life it does not appear radiographically.
4. **Mental fossa:** This is a scooped out depressed area of the bones located on the external surface of the anterior mandible. On radiograph it appears as a radiolucent area above the mental ridge.
5. **Mental foramen:** It is an opening in the bone located in the external surface of the mandible, in the region of the mandibular premolar. Blood vessels and nerves that supply the lower lip exit through the mental foramen. On radiograph, it appears as a small liquid first round radiolucent area located in the apical region of the premolar.
6. **Mandibular canal:** It is a tube-like passage through the bone that travels the length of the mandible. It extends from the mandibular foramen to the mental foramen and houses the inferior alveolar nerve and blood vessels. Radiographically appears as a radiolucent band, outlined by two thin radiopaque lines.
7. **Submandibular fossa:** It is a depressed area of bone located on the internal surface of the mandible inferior to mylohyoid line. It houses the submandibular salivary gland. On radiograph appear as a radiolucent area in the molar region below mylohyoid ridge.

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